Multiscale dynamics and information: from data assimilation to stabilization by noise

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Multiscales occur in physical systems throughout the science and engineering, and reflect different orders of magnitudes of rates of change of different variables. These scales often allow one to find effective behaviors of the fast scales. Reduced models can be used in place of the original complex models and often provide qualitatively accurate and computationally feasible descriptions. The basis of this work is a collection of limit theories for stochastic processes which model dynamical systems with multiple time scales.

The *first part* of this talk combines our results on stochastic dimensional reduction and nonlinear filtering to provide a rigorous framework for identifying reduced order filters which are specifically adapted for multi-scale dynamical systems. In particular, we study how scaling interacts with filtering via stochastic averaging. This talk is focused on some of the theoretical aspects that deal with reduced dimensional nonlinear filters. In particular, we show the efficient utilisation of the low-dimensional models of the signal and develop a low-dimensional filtering equation. We achieve this through the framework of homogenization theory which enables us to average out the effects of the fast variables.

The *second part* of this talk develops methods to suppress machine tool chatter in *turning* processes. Chatter, the self-excited relative vibration between workpiece and cutting tool that grows to prohibitive proportions, is a common problem in the machining process. The variable speed machining, whereby greater widths of cut are achieved by modulating the spindle speed continuously, has received attention in recent years. One of the key findings of our work is that an optimal modulation frequency ν could be determined to achieve greater widths of cut. We show that chatter suppression can be achieved when the spindle speed is varied in a random manner within the bandwidth of the spindle system.

The support of the AFOSR under grant number FA9550-08-1-0206 and the National Science Foundation under grant numbers CNS 05-40237, DMS 05-04581 and CMMI 07-58569 is acknowledged. This is a joint work with Nishanth Lingala, Jun H. Park, Richard B. Sowers, Henry van Roessel and Volker Wihstutz.